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TWO WHEELER PERFORMANCE GAUGING BY ANALYZING THE RELATIONSHIP BETWEEN THE MILEAGE OF VEHICLE AND ITS ASSOCIATED VARIABLES – A GREEN LOGISTICAL APPROACH

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ABSTRACT

Two wheelers utility ratio is rapidly growing with every year in the Asian geographical zones and it also increases the environmental burden. This research work, extracts the data from two scooter type vehicles of different makes on the outskirts of a city in India, during less traffic hours. It identifies six key variables (engine volume (cc), dead weight of vehicle (kg), pneumatic pressure in the tyres, manufactured year, operating speed of vehicle during experimental trials, number of permissible passengers to travel) which can influence the outcome (mileage of vehicle). The methodology utilized in this article is response surface methodology with an objective of maximizing the outcome. The results are inferred from two graphical plots namely: contour plot and a surface plot.

KEYWORDS: Two Wheelers, Engine Volume (cc), Dead Weight of Vehicle (kg) & Mileage of Vehicle

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Original Article

1. INTRODUCTION

The evolution of e-commerce (Amazon) and online renting business on the 21st century, has opened a door for huge volume of two wheeler sales. These business models, prefers faster delivery of goods through rapid transit (two wheelers) for serving their customers. Two wheelers are also available for renting (eg. Driveezy, Bounce) at affordable costs. Statistics from RTO office (Road transport officer), manifests that the number of new two wheelers hits the road is equivalent to 100 (approximately) from each zone of a city (Bangalore) in India, for a day. Therefore, it is an essential requirement of a road user to comprehend the environmental impact of IC engines of two wheelers. Mileage economy has a direct significance on air pollution and greenhouse gas emissions (Alan Mckinnon et al, 2012). Mileage economy can also be influenced by many parameters namely: lack of maintenance, fail to ride at optimum conditions (preferable speed & air pressure in the tyres), with excess passengers (more than two) or having a ride during peak time zones. Moreover, mileage reduction can also contribute to the escalation of environmental costs. Some of the environmental costs((Infras, 2004); (Copert, 2009), (Tremove, 2009)) are: Medical treatment, loss of biodiversity, vegetative damage (*Air pollution*); Personal suffering, Water shortage, flood protection (*Climate change*); Irritation & Sleep disturbances, loss of amenity (*Noise*); Property damage, death & injury to human uses (*Traffic accidents*). The aim of this article is to identify the influencing factors of mileage economy and to detect the intensity of relation between mileage and its associating variables.

2. THEORETICAL BACKGROUND

Logistic companies, are building a major link between customers and manufacturers. The primary operation of a logistic company, is to distribute their goods and it involves lot of transportation. Modern age companies, offer the customers with multiple routes for distributing the products to them, along with the information of environmental effect (Alan Mckinnon et al, 2012) on every routes. Moreover, customers are sensitized with a product's carbon footprint using 'Cradle to Grave' technique. 'Cradle to grave' is an adjective for life cycle carbon auditing of a product, and an outcome of this strategy is to reveal the environmental impact by the product from the 'raw material phase to the finished product. UK road transport federal organization are using two methods to calculate the fuel emissions involved in transportation and they are: emission from 'source' and emission from 'end user'. The former one is calculating the carbon footprint of the process employed in refineries and in petroleum industries, whereas the latter one is the emission from vehicles, after it is charged in fuel stations. Several parallel research activities are tabulated (Table-1) below.

Table 1: Literature Review of Vehicle Capability

S No	Authors, Publication Year	Type	Research Findings
1.	Sirpa Multaharju & Jukka Hallikars,(2015)	Practical (Case study)	This article develops a comparative report on logistic capabilities (low operating cost, environmental sustainability, logistics quality, Speed & reliability) of 3rd party logistics and 4th Party logistics.
2.	Ruth Banomyong et al, (2015)	Thoretical (Performance measures)	Authors did the extensive study on national logistics of Vietnam, which includes the logistic effectiveness of road, rail, water and air modes.
3.	UniMartinsen, Maria Huge-brodin, (2014)	Conceptual (Exploratory study)	This article provides the broad view on environmental practices implemented by logistic service provider (LSP) and shippers.
4.	Paul. R. Murphy & Richard. F., (2003)	Practical (Emprical study)	The research work carried in this article, did a rigorous study on green logistics practices on US and Non-US firms
5.	Karin Isaksson & Maria Huge-brodin, (2013)	Practical (Case study)	This article assess the range of green services offered by various logistic service providers and it provides a comparative report on it.

3. GREEN LOGISTICS

Green logistics is the process of attaining environmental sustainability (Ping. L, 2009) by adopting new practices like green consumption, green production and green marketing. It has also deployed its multifaceted operations, in the influencing sphere of logistics. Green logistics have improved the thermal efficiency of IC engines from 42 to 50% since 2007 and it estimates that the thermal efficiency can be further improved to 55 % (National Academies of science, 2007). The key drivers for adopting green logistics (Eye for transport, 2007) are: Improving customer relations (70%), rate of financial return on investment (60%), decreasing fuel bills (60%) and on. The green logistics is also a potential force to promote products and technologies (Gilmore, 2008), as it is an effective tool to preserve the planet. But, the gauging of logistics and supply chain greening process is difficult (Alan Mckinnon et al, 2012), as it involves multiple process variables. Therefore, a standard template is not sufficient to capture all data into it.

4. PERFORMANCE GAUGING METHODS OF VEHICLES

The performance of a vehicle (Scott. B et al, 2014) is monitored by three kinds of signals (Figure-1) acquired from the vehicle and they are perceptive signals, audible signals and observational (experiential) signals.

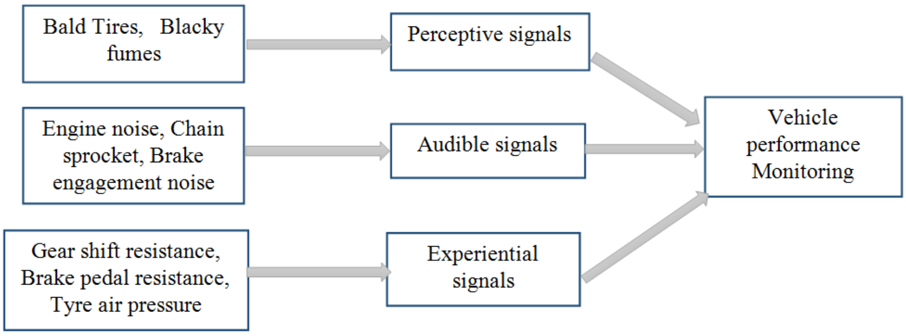

Figure 1: Vehicle Performance Monitoring

An experiment was performed by a researcher team (Ang-olson and Schroeer, (2002)) to find ways to improve the fuel performance of a vehicle. The key parameters considered for improving fuel performance are: Operating speed reduction for vehicle (A), Idling speed reduction (B), Training drivers (C), Aerodynamic profile modification (D), Wide base tyres (E), Non-essential weight reduction (F), usage of low friction lubricants (G), Tyre inflation systems (H). The outcome reveals that, operating speed reduction(A) from 65 Kmph to 60 Kmph, had improved the fuel economy to 7.8%, whereas the aerodynamic profiling and training drivers had improved the fuel economy to 3.8% of its original value.

4.1. Problem Methodology

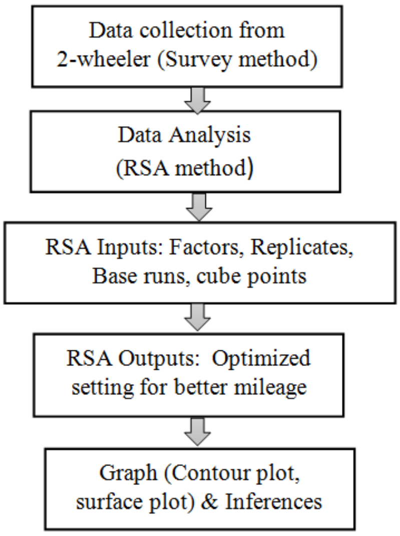

Figure 2: Methodology of Two Wheeler Performance Gauging

The methodology section, explains the flow of the activities (Figure-2) involved in this project. The first step is to collect data from two wheelers of different make (scooter type vehicle). The collected data is then sorted based on: objective function, outcome and the influencing parameters. Response surface analysis (RSA) method is used as a tool for data analysis. It develops many contour plots between input variables and outcomes, along with a surface plot also. RSA method also provides the relationship between preferred input variables and the outcome.

5. CASE STUDY-TWO WHEELER PERFORMANCE GAUGING

5.1 Data Collection

A survey table is designed, and then the data are taken from two vehicles (scooter type), of different make. The data is taken on the outskirts of a particular city in india, and the parameters monitored during ride are: Engine cc (113/125), dead weight of a vehicle (104/101 kg), pneumatic pressure in the tyres (24/34, 25/35), manufactured year (2014/16), vehicle speed (45/55) and number of passengers travelled (1/2). The data are collected by two teams in low traffic time zones between a location-A and location-B.

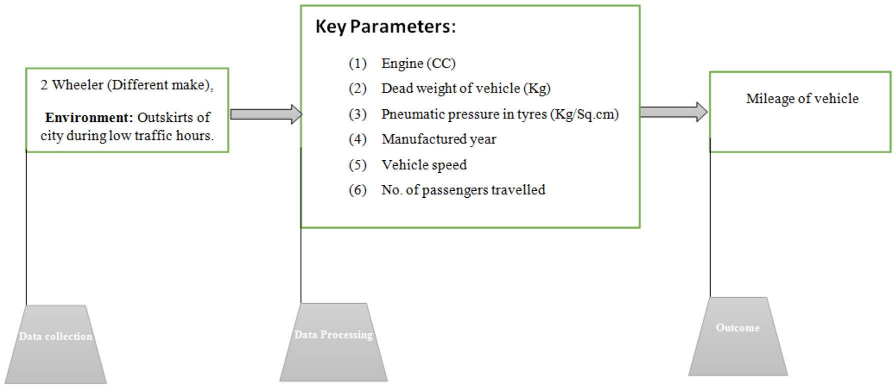

Figure 3: Blue Print of Data Collection

5.2 Data Analysis

The data obtained from two wheelers are sorted and analyzed using response surface analysis (RSA) method. This method establishes the optimum value settings for input parameters to attain the objective function. The input given for the data analysis (Table-2) are 6 factors, 2 levels and 53 iterations.

Table 2: RSA Input Parameters

S No	Details	Values
1.	Factors	6
2.	Base runs/Total runs	53
3.	Two level factorial	Half Fraction
4.	Cube Points	32
5.	Centre points in cube	9
6.	Axial Points	12
7.	Levels	2

Table 3: RSA Output Values

Source	DOF	Adj. SS	Adj. MS	F-Value	P-Value
Model	27	6543.2	242.34	1.59	0.122
Linear	6	1098.0	183.00	1.20	0.337
Engine (A)	1	83.1	83.10	0.55	**0.467**
Front air pressure (B)	1	0.1	0.06	0.00	**0.984**
Rear air pressure (C)	1	155.4	155.40	1.02	0.322
Year of manufacture (D)	1	619.8	619.76	4.08	0.054
Vehicle speed (E)	1	59.2	59.22	0.39	**0.538**
No. of passengers travelled (F)	1	180.5	180.46	1.19	0.286
Square	6	841.6	140.26	0.92	0.495
Engine*Engine	1	27.7	27.69	0.18	0.673
Front air pressure*Front air pressure	1	13.7	13.65	0.09	0.767

Rear air pressure*Rear air pressure	1	11.4	11.44	0.08	0.786
Year of manufacture*Year of manufacture	1	195.4	195.42	1.29	0.268
Vehicle Speed * Vehicle Speed	1	150.7	150.72	0.99	0.329
No. of passengers travelled * No. of passengers travelled	1	592.0	592.03	3.90	0.06
2-Way Interaction	**15**	**4603.6**	**306.91**	**2.02**	**0.058**
Engine*Front air pressure	1	45.6	45.58	0.3	0.589
Engine*Rear air pressure	1	30.6	30.56	0.20	0.658
Engine*Year of manufacture	1	5.4	5.35	0.04	**0.853**
Engine*Vehicle speed	1	283.6	283.64	1.87	0.184
Engine*No. of passengers travelled	1	1025.7	1025.71	6.75	0.016
Front air pressure*Rear air pressure	1	542.6	542.60	3.57	0.07
Front air pressure*Year of manufac.	1	151.3	151.34	1.00	0.328
Front air pressure*Vehicle speed	1	770	769.99	5.07	0.033
Front air pressure.*No. of passengers travelled	1	901.5	901.53	5.93	0.022
Rear air pressure*Year of manufacture	1	45.4	45.39	0.30	0.590
Rear air pressure*Vehicle speed	1	75.9	75.86	0.5	0.486
Source	**DOF**	**Adj.SS**	**Adj.MS**	**F-Value**	**P-Value**
Rear air pressure.*No. of passengers Travelled	1	23.8	23.79	0.16	0.093
Year of manufacture *Vehicle speed	1	462.9	462.92	3.05	**0.696**
Year of manuf.*No. of passengers Travelled	1	238.5	238.55	1.57	0.222
Vehicle Speed *No of passengers travelled	1	0.8	0.85	0.01	**0.941**
Error	**25**	**3799.8**	**151.99**		
Lack of fit	17	2990.8	175.93	1.74	0.215
Pure error	8	809	101.13		
Total	**52**	**10343**			

The output values of RSA method are tabulated in the Table (Table-3). The numerical values of degrees of freedom (DOF), Sum of squares (SS), Mean squares (MS), F-Value (F-Test table), P-Value are captured. Based on the P-value, significance of key parameters on mileage improvement are determined. Main factors which have high influence on outcome (mileage) are: front air pressure-B(0.984), vehicle speed-E (0.538) and volume of an engine-A(0.467) whereas responsible interaction factors : EF (vehicle speed & No. of passengers travelled); AD (volume of an engine & year of manufacture) and DE (year of manufacture & vehicle speed).

6. GRAPHICAL RESULTS

6.1: 2D Graphical Outcome

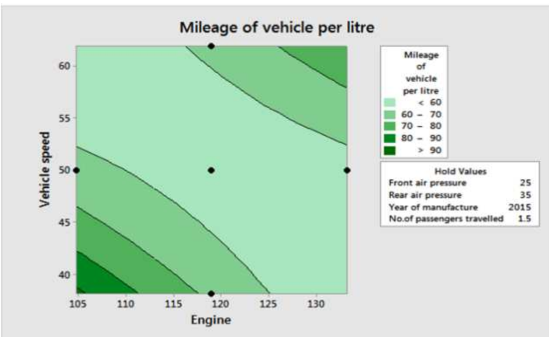

Figure 4: Contour Plot-I (Engine & Vehicle Speed) for Maximum Mileage Efficiency

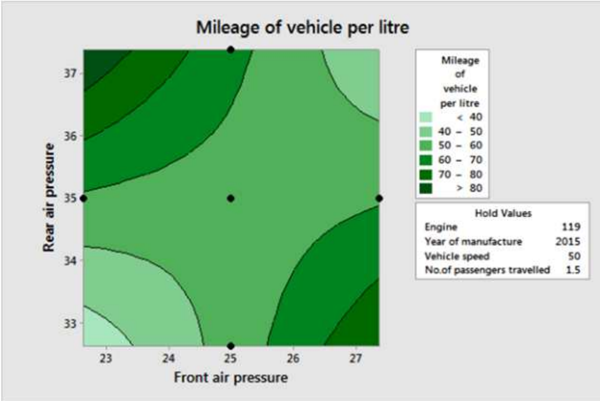

Figure 5: Contour Plot-II (Front air & Rear Air Pressure) for Maximum Mileage Efficiency

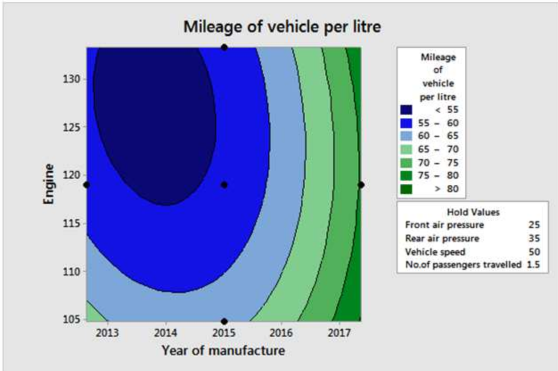

Figure 6: Contour Plot-III (Engine & Year of Manufacture) for Maximum Mileage Efficiency

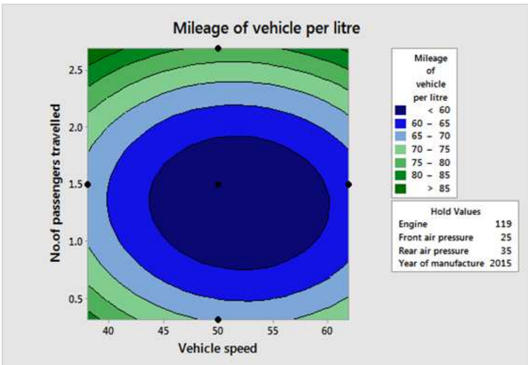

Figure 7: Contour Plot-IV (Vehicle speed & No. of Passengers Travelled) for Maximum Mileage Efficiency

The 2D graphical outcome (Section 6.1), describes the relationship of two key variables with the outcome (mileage of vehicles). In the I graphical outcome (Figure-4), the relationship of *outcome (mileage per litre) with engine volume & vehicle speed* are manifested. The graph (Figure-4), reveals that for attaining the mileage of vehicle (60-70 kilometre per litre); the key variables have to be operated with in the following numerical values (i. e., engine volume =118 cc; vehicle speed = 50 Kmph). In the 2nd graphical outcome (figure-5), the relation between *mileage per liter versus front air & rear air pressure of vehicle* are established. The predicted values of air pressure on front and rear wheels are 25 & 35 Kg/Sq. cm to reach the maximized outcome (mileage per litre). The 3rd graphical outcome, depicts a link of outcome with

engine volume & year of manufacturing. The predicted optimum values for engine volume & year of manufacturing are 118 & 2015 respectively. The 4th graphical outcome establishes the link of vehicle speed & No. of passengers with the outcome. The predicted values are: vehicle speed -50 Kmph& No. of passengers = 1.5 (i. e., 1 passenger).

6.2: Surface Plots

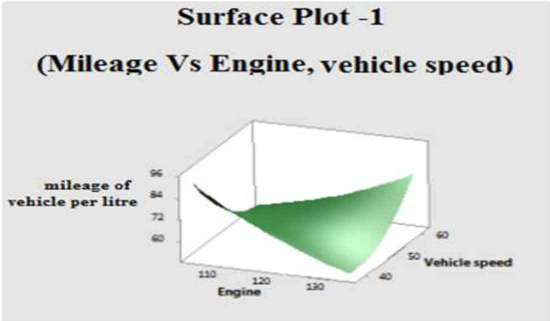

Figure 8: Surface Plot-I (Engine & Vehicle Speed) for Maximum Mileage Efficiency

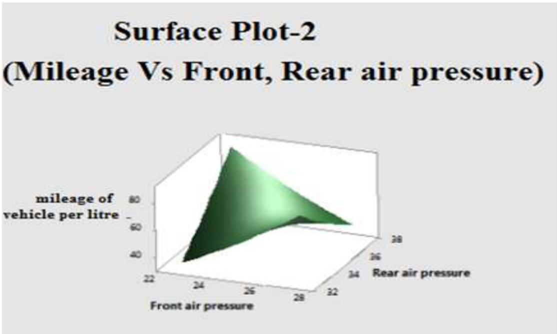

Figure 9: Surface Plot-II (Front & Rear Air Pressure) for Maximum Mileage Efficiency

The surface plot-1 (figure-8) is a three dimensional plot which depicts the interaction of engine volume with the vehicle speed on the outcome (maximum mileage). The curve (figure-8) manifests that, the maximum mileage (96 kmpl) is attained, when the average speed of a vehicle is at 60 kmph for 130 cc (engine volume) engine. Moreover, if the speed declines from 60 to 50 Kmph or even to 40 Kmph (130 cc engine), then the mileage is also reduced (60 kmpl). The surface plot-II (figure-9) predicts that, the maximum mileage (80 kmpl) is attained, when the front and rear wheel air pressure is at optimum values (24 & 36 kg/sq. cm) respectively. Whereas, there is a high probability of decline in mileage, if one or either of the wheels are having lower or higher air pressures than the prescribed values. The surface plot-III (figure-10) estimates that, the maximum yield (mileage) will be attained if two passengers (minimum) are travelling in a vehicle with an optimum (130 cc) engine volume.

7. DISCUSSION OF OUTCOMES

The contour plot and surface plot depicts the interaction between the key variables for providing the maximum outcome. The contour plot provides the discrete values, according to the key variables zones whereas the surface plot produces the continuous relationship between the variables and the outcome. It follows the quadratic relationship with the outcome. Based on the analysis, it is inferred that these plots contribute few optimum variables (Table-4) for maximized

outcome.

Table 4: Optimum Values of Key Variables

Details	Contour Plot Observations	Surface Plot Observations
Outcome value	Mileage per litre**(60-70 Kmpl)**	Mileage per litre**(96 Kmpl)**
Key variable-1	Engine Volume **(118 cc)**	Engine Volume **(130 cc)**
Key variable-2	Dead weight of vehicle **(NA)**	Dead weight of vehicle **(NA)**
Key variable-3	Pneumatic pressure in tyres (Front air pressure =**25 kg/sq. cm** Rear air pressure = **35 kg/sq. cm**)	Pneumatic pressure in tyres (Front air pressure =**24 kg/sq. cm** Rear air pressure = **36 kg/sq. cm**)
Key variable-4	Manufactured year **(2015)**	Manufactured year **(NA)**
Key variable-5	Vehicle speed **(50 Kmph)**	Vehicle speed **(60 Kmph)**
Key variable-6	No. of passengers allowed to travel **(1.5 Passenger= 1 Adult + 1 Kid)**	No. of passengers allowed to travel **(2 Passengers)**

The optimum values attained from the contour plot are attaining the better outcome value (60-70 kmpl) whereas the outcome predicted from the surface plot are reaching the maximum outcome value (96 kmpl). But the key variables predicted by these two plots are validated in the outside city context and based on that the optimum variables suggested by these two plots are ranked. The vehicle speed from contour plot is 50 Kmph whereas the surface plot recommends the speed as 60 Kmph. The former one is acceptable during non-peak traffic time zones inside the city whereas the latter one is highly recommended in outskirts of the city. Hence, the values suggested by the surface plot are reckoned as productive values for this case study, as this research data are captured in the outskirts of city during low traffic hours. The remnant five key variables are adopted on both contexts (both in city rides and outskirts of the city).

8. CONCLUSIONS

As the two wheelers utility is increasing every day, by public as well as the online retail firms for delivery and it also drives to the formation of gap between the sellers and consumers on vehicle's performance. This piece of work has provided an insight on reducing the rift between consumers and manufacturers and to improve the vehicle performance during city rides and on highway roads. Moreover, mileage of vehicle cannot be determined only by the quality of the product (manufacturer's capability) but it needs an equal contribution from consumers also. Some of the efforts to be taken by the consumer are: riding the vehicle at prescribed speeds. Monitoring the vehicle health periodically, replacing the worn-out products with the qualified spare parts and on.

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